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Interim Phase II Remedial Action Report for Organic Contamination in the Vadose Zone Operable Unit 7-08

BECHTEL BWXT IDAHO, LLC

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CONTENTS

1. INTRODUCTION 1-1

1.1 Overview 1-1

1.2 Background 1-1

1.3 Organization of the Phase II RA Report 1-3

2. REMEDIATION ACTIVITIES 2-1

2.1 Operational Sampling and Analysis 2-1

2.2 Environmental Sampling and Analysis 2-2

2.3 Occupational Sampling and Analysis 2-8

3. MODIFICATIONS TO THE REMEDIAL ACTION 3-1

3.1 Modifications to the RD/RAWP 3-1

3.2 Other RA Modifications 3-1

4. SYNOPSIS AND VERIFICATION OF WORK PERFORMED 4-1

4.1 Synopsis of Remedial Action Activities 4-1

4.1.1 Passive Venting 4-1
4.1.2 Barometric Pressure 4-1
4.2 Verification of Work Performed 4-1

5. CERTIFICATION THAT THE REMEDY IS OPERATIONAL AND FUNCTIONAL 5-1

6. CONTINUED PHASE II OPERATIONS STRATEGY 6-1

6.1 VOC Release and Subsurface Transport Modeling 6-1

6.1.1 Flux Chamber 6-2
6.1.2 Inventory 6-2
6.2 SDA/Transuranic Storage Area (TSA) Drilling and Sampling 6-3

6.3 Long-Term Treatment Scenario 6-3

6.4 New Unit Procurement 6-3

6.5 Plan for Well Remedy and Microbial Analysis of Samples Extracted from Wells 3E, 2E, and 3V 6-4

6.6 Feasibility Study for Deep Extraction 6-4

7. PROBLEMS/OBSTACLES ENCOUNTERED AND LESSONS LEARNED 7-1

7.1 OCVZ VVET Unit C Failure Root Analysis Report 7-1

7.2 Independent Engineering Review 7-1

7.3 Unit Operations 7-2

7.3.1 Third Quarter 1997 Operating Cycle 7-2
7.3.2 Fourth Quarter 1997 Operating Cycle 7-2
7.3.3 Mid-Year 1998 Operating Cycle 7-3
7.3.4 End-Year 1998 Operating Cycle 7-3
7.3.5 Mid-Year 1999 Operating Cycle 7-4

8. INTERIM PHASE II COST SUMMARY 8-1

9. SCHEDULE FOR CONTINUATION OF PHASE II ACTIVITIES 9-1

10. ENFORCEABLE MILESTONES 10-1

11. REFERENCES 11-1

FIGURES

1-1. Map of the INEEL Site showing location of major facilities. 1-2

2-1. Analyte mass contribution to total VOC mass (Total 1996-1999 operating/shutdown cycles). 2-3

6-1. Predicted CCl_4 groundwater concentration at the southern SDA boundary showing the effect of: (1) no RA operations, (2) RA operations through 4/1998, and (3) 20, 30, and 50 years of continued current RA operations beyond 1998. 6-2

9-1. Estimated Schedule for Future OCVZ Operations. 9-1

TABLES

2-1. Breakdown per operating cycle of the mass of contaminant removed to date. 2-4

2-2. Cumulative operating schedule of the VVET system 2-6

8-1. Estimated cost for the Interim Phase II operations. 8-1

ACRONYMS

B&K	Brüel and Kjaer
bls	below land surface
CCl_4	carbon tetrachloride
CFR	Code of Federal Regulations
$CHCl_3$	chloroform
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
DUST	Disposal Unit Source Term
FFA/CO	Federal Facility Agreement and Consent Order
HCl	hydrogen chloride
IDHW	Idaho Department of Health and Welfare
INEEL	Idaho National Engineering and Environmental Laboratory
IRM	iron reducing media
LMITCO	Lockheed Martin Idaho Technologies Company
MCL	maximum contaminant level
Mg	megagram
OCVZ	Organic Contamination in the Vadose Zone
OP-FTIR	Open-Path Fourier Transform Infrared Spectroscopy
OU	operable unit
Parsons	Parsons Infrastructure and Technology Group Inc.
PCE	tetrachloroethene
PLC	programmable logic controllers
RA	remedial action
RAO	remedial action objectives

RAWP	RA Work Plan
RD	remedial design
RFTO	recuperative flameless thermal oxidation
ROD	Record of Decision
RPD	relative percent difference
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SO	system operability
SRPA	Snake River Plain Aquifer
TCA	trichloroethylene
TCE	1,1,1-trichloroethane
TSA	Transuranic Storage Area
TSB	tryptic soy broth
VOC	volatile organic compound
VVET	vapor vacuum extraction with treatment
WAG	waste area group

Interim Phase II Remedial Action Report for Organic Contamination in the Vadose Zone Operable Unit 7-08

1. INTRODUCTION

1.1 Overview

In accordance with the Federal Facility Agreement and Consent Order (FFA/CO), the U.S. Department of Energy (DOE) submits the following Interim Phase II Remedial Action (RA) Report for the Organic Contamination in the Vadose Zone (OCVZ) RA at the Radioactive Waste Management Complex (RWMC), designated as Waste Area Group (WAG) 7, Operable Unit (OU) 7-08 of the Idaho National Engineering and Environmental Laboratory (INEEL). The purpose of this report is to describe and document the activities performed from July 1997 through July 1999 for the Interim Phase II RA.

The objective of the RA, as stated in the OU 7-08 Record of Decision (ROD) (U.S. Department of Energy Idaho Operations Office [DOE-ID 1994]), is to reduce the risks to human health and the environment associated with the organic contaminants present in the vadose zone and to prevent federal and state safe drinking water standards from being exceeded in the future. As stated in the ROD, the remedy selected to accomplish this objective is vapor vacuum extraction with treatment (VVET). Vapor vacuum extraction with treatment involves extraction of the organic contaminants from the subsurface and subsequent destruction of the contaminants at the surface by means of a recuperative flameless thermal oxidation (RFTO) process.

The Interim Phase II remediation activities are being performed in accordance with the remedial design (RD)/RA work plan (RAWP) (Scientech 1995).

1.2 Background

The RWMC is located in the southwest portion of the INEEL (Figure 1-1) and was established in 1952 as a disposal site for solid low-level radioactive waste generated by the INEEL and other DOE operations. It encompasses approximately 704,178 m^2 (174 acres) and consists of three main areas: (1) the Subsurface Disposal Area (SDA), (2) the Transuranic Storage Area (TSA), and (3) an Administrative Area.

Within the SDA are individual storage and disposal areas consisting of: pits, trenches, aboveground storage pads, and soil vaults. The presence of organic contaminants in the vadose zone beneath the RWMC is a result of the burial and subsequent breach of containerized organic wastes, primarily from the Rocky Flats Plant in several of the pits and trenches. The organic wastes were mixed with calcium silicate to reduce free liquids and form a grease like material, which was typically double bagged and placed in drums prior to disposal. In addition, small amounts of absorbent, such as Oil-Dri, were normally mixed with the waste to bind free liquids. The organic wastes consisted of lathe coolant,

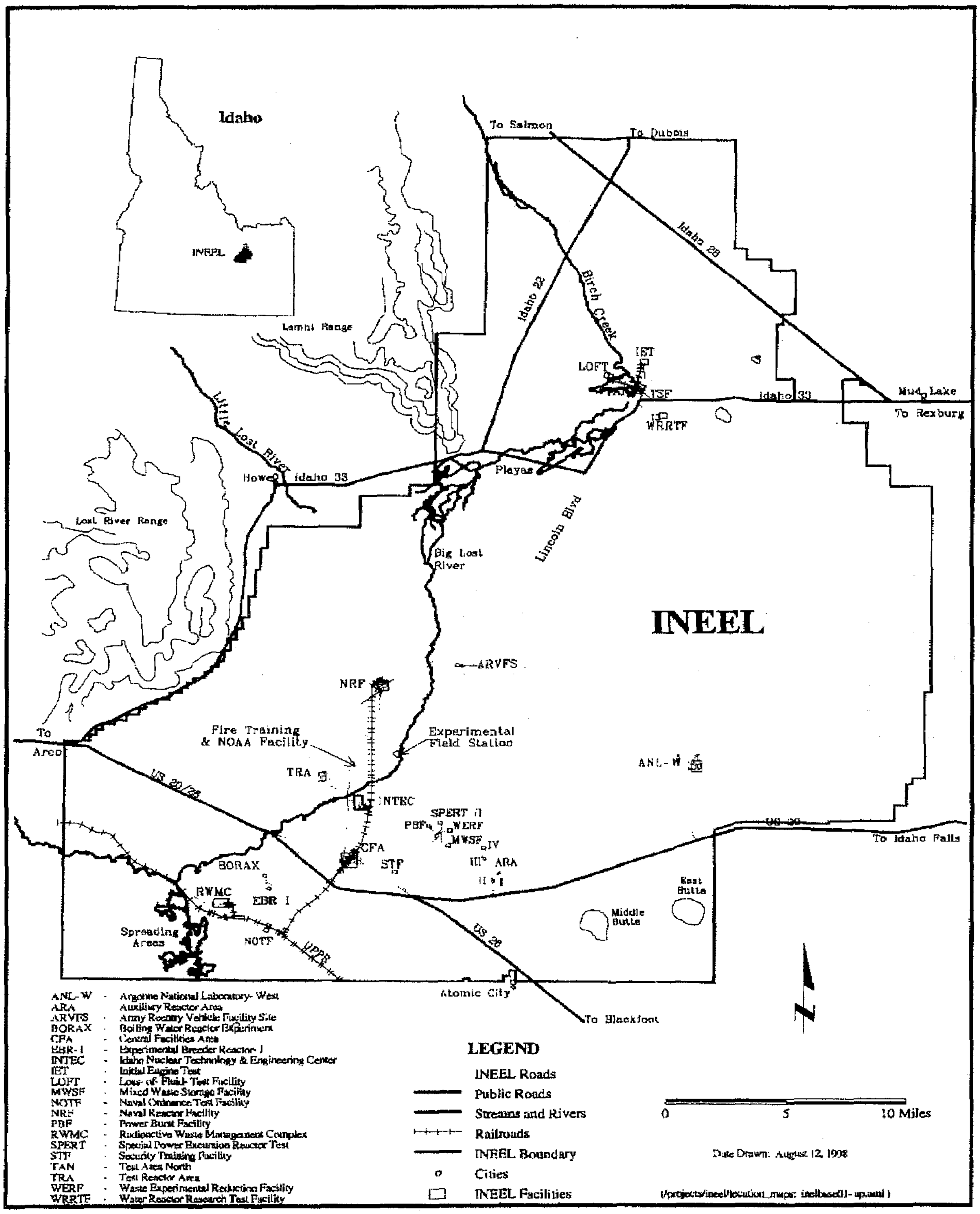

Figure 1-1. Map of the INEEL Site showing location of major facilities.

used oils, and degreasing agents such as carbon tetrachloride (CCl_4), 1,1,1-trichloroethane (TCA), trichloroethene (TCE), tetrachloroethene (PCE), hydraulic oil, gearbox oil, spindle oil, freon, and varsol, etc. (Clements 1982). Over time, the containers of organic wastes have deteriorated, allowing volatile organic compound (VOC) contaminants to migrate into the vadose zone. The vadose zone has subsequently become contaminated with VOCs, and trace levels (low parts per billion) of CCl_4 have been detected in the underlying Snake River Plain Aquifer (SRPA).

Operable Unit 7-08 is defined as that part of the vadose zone beneath and within the immediate vicinity of the RWMC, exclusive of the disposal pits and trenches. As such, the OU extends from the bottom of the disposal pits and trenches to the top of the SRPA, which lies about 177 m (580 feet) below the facility.

1.3 Organization of the Phase II RA Report

The report summarizes the RA activities (Section 2) and identifies modifications to the RD/RAWP (Section 3). Next, a synopsis and verification of work performed is presented (Section 4), followed by a certification that the remedy is operational and functional (Section 5), a discussion of the continued phase II strategy (Section 6), problems and obstacles encountered and lessons learned to date for the RA (Section 7), a brief summary of the costs for Interim Phase II (Section 8), schedule for Phase II continuance (Section 9), and the enforceable milestones (Section 10).

2. REMEDIATION ACTIVITIES

The Interim Phase II of the OCVZ RA consisted of several activities, including site operation, maintenance, and monitoring of the VVET units, monitoring of the subsurface VOC concentrations, occupational monitoring, VOC release and subsurface modeling, and source inventory calculations. These activities are discussed in detail in the following sections.

2.1 Operational Sampling and Analysis

Prior to startup of VVET system operations, baseline vapor samples were collected on January 4, 1996, from all vapor monitoring ports in the extraction and monitoring wells. These results are included in each data report.

Samples from the units have been continued to be collected when the units were running and analyzed using the Brüel and Kjaer (B&K) Model 1302 Multi-Gas Analyzers. The mass removal is calculated using the operational sample data and flow rate. The samples were collected and analyzed per the *Post-Record of Decision Optimization Plan,* Appendix J of the *Remedial Design/Remedial Action Workplan, Organic Contamination in the Vadose Zone, Radioactive Waste Management Complex Subsurface Disposal Area*, (Scientech 1995).

The Interim Phase II RA continued from the Phase I RA in the third quarter operating/shutdown cycle of 1997. The third quarter operating/shutdown cycle began May 7, 1997 and continued through August 27, 1997. Detailed information is available in *Organic Contamination in the Vadose Zone Environmental and Operational Data Report Third Quarter Operating/Shutdown Cycle 1997* (INEEL 1998a). All three units were shutdown on July 24, 1997, to allow a scheduled upgrade of the programmable logic controller in each unit to be conducted. The units remained shutdown until the upgrade was completed and the program logic tested on September 4, 1997.

The fourth quarter operating/shutdown cycle began September 4, 1997 and continued through December 22, 1997. Further information is outlined in *Organic Contamination in the Vadose Zone Environmental and Operational Data Report Fourth Quarter Operating/Shutdown Cycle 1997* (INEEL 1998b).

The mid-year operating/shutdown cycle of 1998 began January 1, 1998 and continued through June 25, 1998. The information for this report is detailed in *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, Mid-Year Operating/Shutdown Cycle 1998* (INEEL 1998c). A rebound period was arbitrarily set by the project team from April 30 through June 25. Evaluation of the rebound data indicated that VOC concentrations generally reached equilibrium, although a few vapor ports had not at the end of the rebound period. A decision was made by DOE-ID and the project team to restart the units anyway.

The Interim Phase II operations were changed to a non-stop operation mode, consisting of a continuous operations phase and no shutdown phase beginning with the end-year operating/shutdown cycle of 1998. The end-year operating/shutdown cycle of 1998 began June 26, 1998 and continued through December 31, 1998 as outlined in *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, End-Year Operating/Shutdown Cycle 1998* (INEEL 1999a).

The mid-year operating/shutdown cycle of 1999 began on January 1, 1999, and continued through July 25, 1999. Details of this report are in *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, Mid-Year Operating/Shutdown Cycle 1999* (INEEL 1999b). The reporting period was extended from the end of June to the end of July to allow collection of the second quarter sample round. The units were not operational during the first quarter of 1999 to allow collection of quarterly samples at that time.

During all operating/shutdown cycles, unit operations were maintained and monitored daily (based on a 4-day work week) by a full-time operator. Daily routine maintenance was performed, daily influent VOC samples were collected, daily operations logs and reports were maintained, and trouble-shooting activities were performed as necessary.

Figure 2-1 provides the analyte mass contribution to total VOC mass from all operational cycles through July 25, 1999 for the five analytes, including chloroform ($CHCl_3$), TCA, PCE, TCE, and CCl_4 (INEEL 1999b). Table 2-1 provides the operational cycle dates, amount of each analyte removed, and the total VOCs removed per cycle (INEEL 1999b).

Since startup of the VVET system in January 1996, the three units operated for a combined total of 38,092 hours out of the 64,257 available operating hours, and removed a combined total of 27,806 kg (61,173 lb) of VOCs. The total operating hours represent an overall system uptime of 59%. This number, however, includes several unplanned downtimes as discussed in Section 7.3. The described events significantly reduced the overall percentage of system uptime. The percent of system uptime is shown in Table 2-2 (INEEL 1999b).

2.2 Environmental Sampling and Analysis

The objective of the sampling activities for the OCVZ operation is to obtain representative extraction and monitoring well vapor samples of a known quality to help assess the effectiveness of the selected remedy and to optimize mass removal of organic vapors from the vadose zone. A total of 20 wells within the SDA were used for monitoring purposes during operations. These wells have from one to four ports per well, ranging in depth from 9.91 to 73.2 m (32.5 to 240 ft) below land surface (bls). A total of 63 vapor ports exist from which samples were collected. These samples were also collected and analyzed in accordance with Appendix J of the RD/RAWP.

Precision, accuracy, completeness, and comparability are discussed in each of the individual operating cycle data reports. The quality of data obtained during the Interim Phase II activities (July 1997 through July 1999) was ensured through measurements of precision and accuracy. Precision was determined by calculating the relative percent difference (RPD) for both the field duplicates and the field splits. The majority of exceedances of the RPD goal of 30% was for samples with concentrations less than 25 ppmv. The measurement precision of the B&K monitor decreased as sample concentrations approached the 1 ppmv detection limit of the instrument. Accuracy was determined through analysis of standard gas samples. Except for a few exceedances, the accuracy of the B&K monitors was within 20% of the known values of the standards.

The percent completeness of the operating cycles (July 1997 through July 1999) averaged over 86%. Comparability between data operating cycles was ensured by following the same field collection, sample handling methods, and analyzing samples using the same field instrumentation.

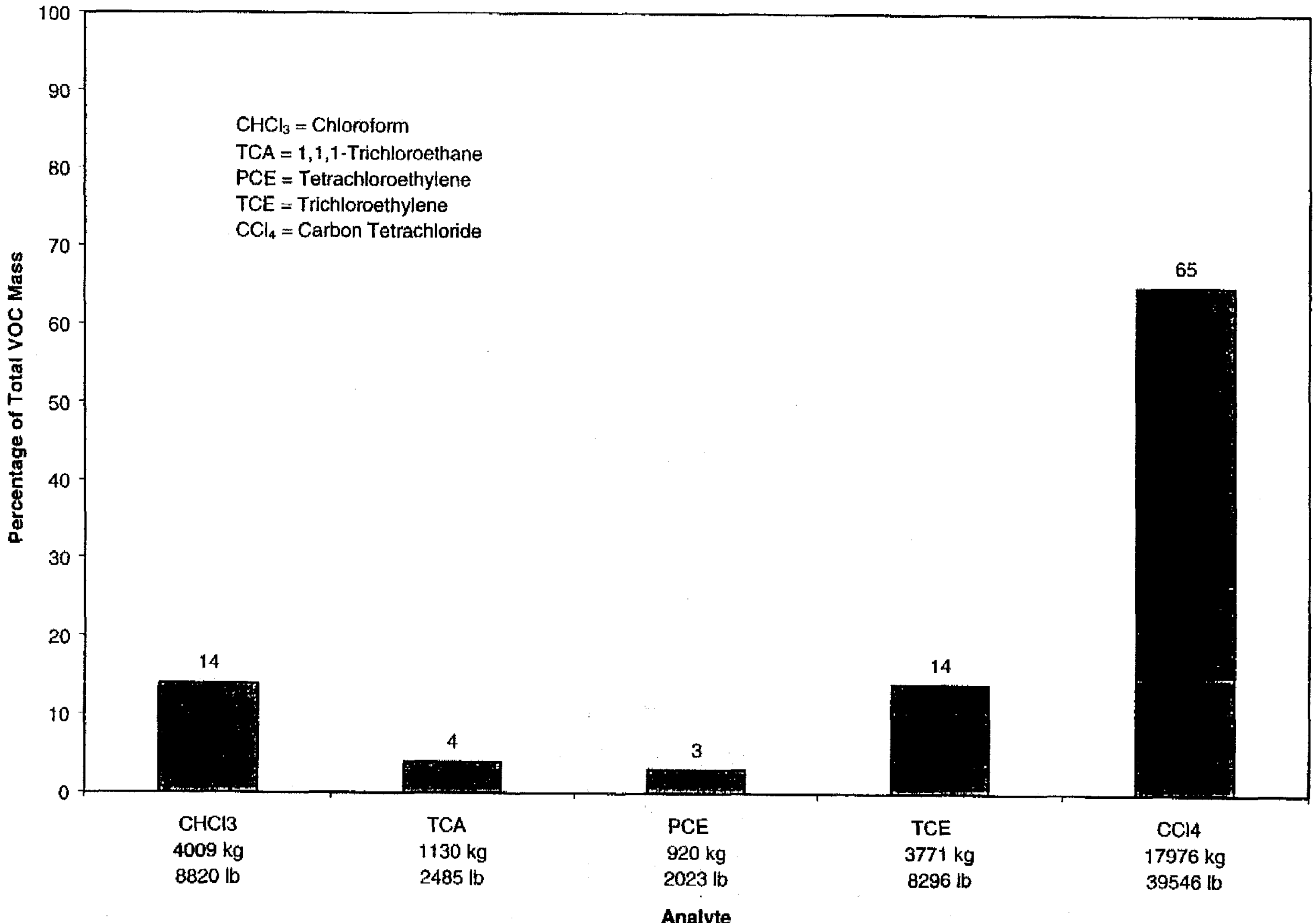

Figure 2-1. Analyte mass contribution to total VOC mass (Total 1996-1999 operating/shutdown cycles).

Table 2-1. Breakdown per operating cycle of the mass of contaminant removed to date.

Operating Period	Year	$CHCl_3$ (kg)	TCA (kg)	PCE (kg)	TCE (kg)	CCl_4 (kg)	Total (kg)
First Eight-Week	1996	510	151	106	461	2277	3505
Percentage of Total		15	4	3	13	65	
Second Eight-Week	1996	258	80	64	247	1203	1853
Percentage of Total		14	4	3	13	65	
Third Eight-Week	1996	169	51	36	151	753	1159
Percentage of Total		15	4	3	13	65	
First Quarter	1997	196	48	28	142	857	1270
Percentage of Total		15	4	2	11	67	
Second Quarter	1997	497	165	134	494	2393	3684
Percentage of Total		13	4	4	13	65	
Third Quarter	1997	291	54	65	273	1266	1949
Percentage of Total		15	3	3	14	65	
Fourth Quarter	1997	547	155	110	449	2452	3713
Percentage of Total		15	4	3	12	66	

Table 2-1. (continued).

Operating Period	Year	$CHCl_3$ (kg)	TCA (kg)	PCE (kg)	TCE (kg)	CCl_4 (kg)	Total (kg)
Mid-Year	1998	489	153	112	436	2147	3337
Percentage of Total		15	5	3	13	64	
End-Year	1998	674	175	191	714	2768	4523
Percentage of Total		15	4	4	16	61	
Mid-Year	1999	378	98	74	404	1860	2814
Percentage of Total		13	4	3	14	66	
Total	1996-1998	4009	1130	920	3771	17976	27806
Percentage of Total		14	4	3	14	65	

$CHCl_3$ = Chloroform

TCA = Trichloroethane

PCE = Tetrachloroethylene

TCE = Trichloroethylene

CCl_4 = Carbon tetrachloride

Table 2-2. Cumulative operating schedule of the VVET system.

Year		Unit A (hour)	Unit B (hour)	Unit C (hour)
1996	First Eight-Week			
	Hours Operated	1321	1137	1102
	Hours Available	1602	1437	1265
	Percent Operated	82	79	87
1996	Second Eight-Week			
	Hours Operated	916	614	915
	Hours Available	994	971	994
	Percent Operated	92	63	92
1996	Third Eight-Week			
	Hours Operated	750	640	752
	Hours Available	1008	864	1056
	Percent Operated	74	74	71
1997	First Quarter			
	Hours Operated	120	744	1056
	Hours Available	2952	2952	2952
	Percent Operated	4	25	36
1997	Second Quarter			
	Hours Operated	899	1223	1355
	Hours Available	1023	1531	1633
	Percent Operated	88	80	83
1997	Third Quarter			
	Hours Operated	824	764	898
	Hours Available	954	817	912
	Percent Operated	86	94	98
1997	Fourth Quarter			
	Hours Operated	2776	2677	160
	Hours Available	2845	2840	2848
	Percent Operated	98	94	6

Table 2-2. (continued)

Year		Unit A (hour)	Unit B (hour)	Unit C (hour)
1998	Mid-Year			
	Hours Operated	2821	2639	0
	Hours Available	2880	2880	2880
	Percent Operated	98	92	0
1998	End-Year			
	Hours Operated	3809	3713	0
	Hours Available	4200	4152	4104
	Percent Operated	91	90	0
1999	Mid-Year			
	Hours Operated	3162	305	0
	Hours Available	4152	407	4152
	Percent Operated	76	75	0
1996-1999	Total			
	Hours Operated	17398	14456	6238
	Hours Available	22610	18851	22796
	Percent Operated	77	77	27

2.3 Occupational Sampling and Analysis

In order to ensure that OCVZ operations are protective of RWMC workers, sampling of hydrogen chloride (HCl) emissions from the three VVE units is currently being performed. The sampling was started on July 1, 1999 and was initially setup to monitor the emissions from Unit A. The sampling equipment consists of an Open-Path Fourier Transform Infrared Spectroscopy (OP-FTIR); which monitors for a range of compounds, including, but not limited to:

- carbon tetrachloride
- chloroform
- 1,1,1-trichloroethane
- dichloromethane
- Freon 113 (1,1,2-trichlorotrifluoroethane)
- trichloroethylene
- tetrachloroethylene
- propane
- hydrogen chloride vapor.

The OP-FTIR is a spectrometer with an attached telescope that emits infrared light through the atmosphere to a retroflector. The retroflector contains a mirror assembly that reflects light back to the spectrometer. Both the spectrometer and retroflector are tripod mounted, enabling them to be adjusted to the desired monitoring height. Currently, both units are set at 1.5 m (5 ft) in order to represent an average human receptor breathing zone. Data collected from the spectrometer is logged onto a laptop computer. The concentration for each contaminant is calculated by comparing the observed constituent peak height to a known standard peak height, as well as incorporating local meteorological data. The calculated concentrations are then plotted versus monitoring time.

The OP-FTIR unit was moved to capture the emissions from Unit B on August 25, 1999 and continues to do so. The unit will be moved to Unit C once 1 week of continuous data is logged from the emissions of Unit B. Future HCl investigations will involve inline monitoring of the stacks on each of the three OCVZ units. The data obtained from the stack monitoring will be correlated with the data obtained from the OP-FTIR units.

3. MODIFICATIONS TO THE REMEDIAL ACTION

3.1 Modifications to the RD/RAWP

Several modifications were made to the original VVET system design, construction, and operation, as specified in the RD/RAWP: (1) a propane flow meter was installed on Unit C, (2) Well 7V was re-piped from Unit C to Unit A following catastrophic failure of Unit C, (3) Unit B is extracting from Well 2E only after Well 3E apparently plugged and was unable to be extracted from, (4) inspection ports were installed on the three VVET units, (5) thermocouples were installed in the tubesheet of each VVET unit to monitor temperature, and (6) propane flowrate into each VVET unit was adjusted per the manufacturer's specifications. Additional information on these modifications is provided in Section 7.3.

3.2 Other RA Modifications

Several other modifications were made to the VVET system operations and monitoring activities during Phase II operations as described in detail in Section 7.3. These modifications were made based on data acquired during unit operations, on best management practice decisions and on direction from project management and the Agencies. The most significant changes include the following: (1) unit operations were changed from operating/rebound cycles (e.g., 4 days on and 3 days off) to continuous operations (24 hours per day), (2) Unit C was rebuilt twice due to catastrophic failures of the unit, (3) Unit B was rebuilt following discovery of damaged tubes in its oxidizer, (4) vapor monitoring was reduced from sampling all vapor ports in all wells monthly to sampling a limited number of specific vapor ports monthly and all vapor ports quarterly (Section 2.1), and (5) a system was set up to allow stack emissions from each unit to be monitored periodically for HCl (Section 2.3).

4. SYNOPSIS AND VERIFICATION OF WORK PERFORMED

This section provides a brief summary of the work performed to date for the OCVZ RA and identifies the documentation which verifies performance of the work.

4.1 Synopsis of Remedial Action Activities

The Interim Phase II remedial operations have continued since October 1997; the end-date of the Phase I RA report. Unit A and Unit B have remained operational, although Unit C went down on September 1997, due to a catastrophic failure. Unit C was rebuilt and subsequently failed again on December 17, 1998. Unit A has ran continuously to date, while Unit B went down for a period of approximately 7 months (January through August) in 1999 due to failure of the oxidizer tubes. Unit B was rebuilt, restarted, and has been operational since August 1999. Unit C has been rebuilt and is currently being system operability (SO) tested, and is expected to begin operation in September 1999. As of July 1999, a total of 27,806 kg (61,173 lb) of total VOCs have been removed from the vadose zone since the beginning of operations in January 1996.

4.1.1 Passive Venting

Passive venting was initially evaluated in a study detailed in Lowry et al. 1998. As stated in the abstract of that document, the report documents the design evolution, field installation, and monitoring results of the original passive venting configuration. The data in this interim report showed a possible correlation between increased vapor flow through the system with elevated wind speeds. Overall, the first report concluded that a modification to the original design was needed in order to make use of the high wind speeds encountered at the RWMC. A second report, Lowry et al. 1999, was issued based on the incorporation of the proposed design changes. In the second report, an increase in vapor flow through the system of up to four times that of naturally occurring release was found; whereas the original design only allowed for one order of magnitude higher than naturally occurring. The report also concluded that additional holes within the treatment area may enhance flow though the system.

4.1.2 Barometric Pressure

During the Interim Phase II RA, subsurface pressure data was collected at various well locations within the SDA. This data was intended to provide a means of inferring the extent to which current extraction operations are actively effecting subsurface contamination. The acquisition phase of this subsurface pressure monitoring activity was recently completed, which resulted in several hundred thousand data points. This large quantity of data will now be evaluated through various mathematical and statistical means in order to estimate the extent of current and future extraction operations. This information will be used to refine any remedial design enhancements which may take place in future phases of VVET operations.

4.2 Verification of Work Performed

Verification of work activities completed was documented on a daily basis. The operator completed daily force reports to document the progress of each day's activities. These reports include activities such as scheduled and unscheduled maintenance, propane deliveries, visitors, inspections, etc. In addition, the operator kept an operations log and recorded the operational parameters of each unit daily.

Data reports were initially prepared per quarter. Currently, data reports are prepared twice per year: a mid-year report and an end-year report. The reports summarize the results of all operational and environmental sampling activities conducted during the cycle and document the mass of VOCs removed during the cycle. In addition, the reports keep a cumulative total of the mass of VOCs removed since the start of remediation.

5. CERTIFICATION THAT THE REMEDY IS OPERATIONAL AND FUNCTIONAL

Pursuant to CERCLA regulations "[a] remedy becomes "operational and functional" either one year after construction is complete, or when the remedy is determined concurrently by EPA and the state to be functioning properly and is performing as designed, whichever is earlier" (40 CFR 300.435.(f)(2). The OU 7-08 remedy was reported to be "operational and functional" in September of 1997 as part of the "Phase I Remedial Action Report for Organic Contamination in the Vadose Zone Operable Unit 7-08" (INEL/EXT-97-00811) and continues to be operational through this interim reporting period.

6. CONTINUED PHASE II OPERATIONS STRATEGY

To date, Interim Phase II operations have removed approximately 18,171 kg (39,976 lb) of CCl_4 from the subsurface beneath the SDA and continue to achieve significant mass removal. Although two of the VVET units experienced downtime during Interim Phase II activities, VVET continues to be an effective remedial action. In Summer of 2002, a Phase III operations strategy will be developed and submitted to the Agencies for review. This document will identify the proposed Phase III activities.

6.1 VOC Release and Subsurface Transport Modeling

A model of VOC release and subsurface transport has been developed for OU 7-08 and is being used to determine and predict the effectiveness of current activities and future RA operations (soil vapor extraction system) in meeting the OU 7-08 ROD objectives. The model was developed for the OU 7-13/14 interim risk assessment and is the most comprehensive model developed thus far for predicting water and contaminant movement in the SDA subsurface. The model includes spatially variable lithology and time-dependent, spatially variable water infiltration in an integrated vadose zone-saturated zone (aquifer) representation. Contaminants move by diffusive and advective mechanisms in aqueous and gaseous phases. The model has been implemented using the numerical simulation code TETRAD. Time dependent releases of VOCs are calculated external to the TETRAD simulator using the Disposal Unit Source Term (DUST) code. Additional details of the model including assumptions, parameterization, calibration, and uncertainty are described in (INEEL 1998d) and (INEEL 1998e).

The most recent and revealing modeling results indicate the current soil vapor extraction system may be incapable of preventing future groundwater contamination above current safe drinking water standards. For example, if the current system of four extraction wells (2E, 3E, 4E, and 7V) were operated an additional 20 to 50 years beyond 1998, CCl_4 concentrations in groundwater at the southern boundary of the SDA are predicted to still be higher than the maximum contaminant level (MCL) of 5 μg/L after the 100-year institutional control period. Figure 6-1 presents the predicted CCl_4 groundwater concentration at the southern SDA boundary showing the effect of: (1) no RA operations, (2) RA operations through 4/1998, and (3) 20, 30, and 50 years of continued current RA operations beyond 1998 This happens because contamination in the lower vadose zone, below the C-D (72 m [240-ft]) interbed is essentially beyond the reach of the current system, yet capable of contaminating the aquifer above acceptable levels. Even though the current system is removing a significant amount of contamination from the upper vadose zone and significantly reducing the amount of contamination ultimately predicted to reach the aquifer, it appears there will come a time when additional pumping will not be effective in achieving the MCL goal.

Although the model has been calibrated using an exceptionally large data set of vadose zone vapor data, groundwater data, perched water data, and flux chamber data, uncertainties exist that make model predictions uncertain. Some of the most important data gaps and model uncertainties identified thus far include: (1) contaminant mass/concentration below the C-D (72 m [240-ft]) interbed inside the SDA boundary, (2) initial VOC inventory/mass (Section 6.1.2), and (3) VOC release rate parameters. Contaminant mass in the deep vadose zone is being addressed by installation of a deep monitoring/extraction well inside the SDA. Work to determine a more defensible inventory/mass estimate is nearly complete, and indications are the mass estimate is larger than the one used to calibrate the current model (as described in the first paragraph of this section). Uncertainty in release rate parameters is being addressed through flux chamber studies and has been addressed in sludge diffusion studies. A diffusion coefficient for the sludge was calculated as a result of the sludge diffusion studies. The report on these studies will be issued in the Fall of 1999. Using the calculated diffusion coefficient of the sludge, a numerical modeling effort is underway both theoretically and on a lab-scale to determine the amount of VOC that will release from the sludges.

Once the new inventory estimate, release rate parameters, and deep vadose zone contaminant concentrations have been determined, a recalibration of the model will likely be necessary.

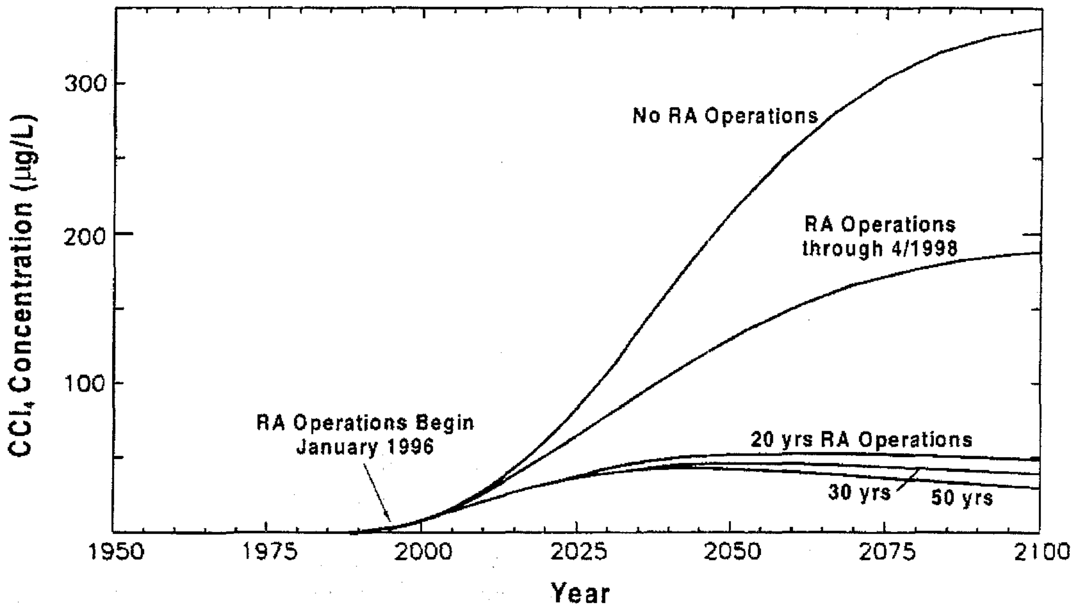

Figure 6-1. Predicted CCl_4 groundwater concentration at the southern SDA boundary showing the effect of: (1) no RA operations, (2) RA operations through 4/1998, and (3) 20, 30, and 50 years of continued current RA operations beyond 1998.

6.1.1 Flux Chamber

During Phase II operations, the need became apparent to quantify the mass of contamination being released from the waste through the overburden into the atmosphere. The information was needed to both determine if significant contaminant mass remains in the source pits and to provide modeling parameters (i.e., tortuosity) to be used in calibration of predictive models. A sophisticated flux chamber system was designed and fabricated in order to quantify the temporal and spatial variability of contaminant surface flux. The flux chamber system was delivered to the INEEL in September of 1999 and will be used to provide the necessary modeling parameters beginning in Fiscal Year 2000. A test plan outlining the specific details of the flux chamber data collection will be completed, reviewed, and approved prior to deployment of the flux chamber.

6.1.2 Inventory

The original CCl_4 mass disposed of in the SDA was estimated to be 119,750 kg (264,000 lb) (EG&G 1985). In March 1998, a report (INEEL 1998f) was issued which represented a revision to original estimates (EG&G 1985) of the mass of VOCs buried in the SDA. The average of the revised estimates of CCl_4 was 490 Mg (540 ton), more than a factor of four greater than the original estimate.

This revision significantly increased the estimate of VOCs thought to have been buried in the SDA and was based primarily on a re-evaluation of the same historical data used in the original work (EG&G 1985). Since that revision, new information has become available that has allowed for corroboration of work in INEEL 1998f. This new information consists primarily of Rocky Flats Plant logbook data, including individual drum weights, which in combination with newly acquired near surface soil gas measurements have enabled the estimation of VOC mass fractions in the active source area. These pieces of information form the basis for a second revision to the original source term estimate, which the revision is designed to corroborate the findings of the first revision and to serve as the authoritative source of information concerning the inventory of VOCs buried in the SDA. Preliminary findings corroborate the estimates in the INEEL 1998f. The second revision of the VOC source inventory is anticipated in Spring of 2000.

6.2 SDA/Transuranic Storage Area (TSA) Drilling and Sampling

The SDA/TSA drilling and sampling project will consist of drilling and sampling 12 monitoring wells in six locations. One of these locations directly supports OCVZ. A data gap exists in terms of concentrations of VOCs below the 72 m (240 ft) interbed. These wells will allow collection of this critical data.

Location I-5 in the SDA will be completed with three monitoring wells. One well will be completed in the vadose zone with three vapor ports and one vapor extraction zone at the 72-m (240-ft) interbed if perched water is not encountered at the 33-m (110 ft) interbed. The first aquifer well will be completed approximately 144 m (480 ft) bls with three vapor ports and one vapor extraction zone between the 72-m (240-ft) interbed and total depth. The second aquifer well will be completed at approximately 189 m (620 ft) bls. The well will be completed with a screen in the aquifer along with three vapor ports and one extraction zone above the water level and below the 72-m (240-ft) interbed. For the two aquifer wells, there will be a total of six vapor ports, two extraction zones, and one screened interval in the water table.

The deep wells are expected to be completed in Fall of 1999.

6.3 Long-Term Treatment Scenario

An independent evaluation of the long-term treatment strategy for the OCVZ project is currently being performed. This effort will consist of a review of the current VVET system, with recommendations for enhancements or modifications to the existing system for greater and more efficient VOC recovery. Potential alternate extraction and treatment methods will also be evaluated for application to the OCVZ site, to either compliment or replace the current system. Remedial action objectives and the overall project goals will be considered during this evaluation. A summary report will be prepared and submitted to the Agencies for review and discussion.

6.4 New Unit Procurement

Due to the inconsistent availability of existing OU 7-08 operating systems, it was determined in Fiscal Year 1999 to purchase a new VVET unit. This procurement is currently underway and in the bid phase of the procurement cycle. The precise application of this new VVET unit will be determined by a variety of factors, including the ability to place existing VVET into operation, the completion of several deep wells currently being drilled in the SDA (Section 6.2), and the results of feasibility studies investigating the potential of deep well extraction (Section 6.6). The new VVET unit is scheduled to be available in the Summer of 2001.

6.5 Plan for Well Remedy and Microbial Analysis of Samples Extracted from Wells 3E, 4E, and 3V

Sampling will be performed to determine whether microbial growth and activity is the primary cause of plugging in two extraction wells, 3E and 4E, and one monitoring well, 3V, within the SDA at the RWMC. If microbial biomass is determined to be the cause of plugging, methods to prevent plugging in other wells will be investigated.

The wells were installed in 1994. The two extraction wells became plugged after approximately two years of operation and the monitoring well became plugged immediately after an attempt to extract from the well. Video logs of the well casing indicated a black, viscous liquid on the internal surface of the well casing near the extraction zone.

Samples of the black substance will be analyzed for the purpose of determining chemical and microbiological content of the samples. Analyses include carbon, nitrogen and hydrogen ratios and enrichments for total heterotrophs, facultative iron-reducing bacteria and sulfate reducing bacteria. Plans are also in place to remove the slotted casing sections from all three wells as an attempt to make the wells operable.

Sampling and ream-out activities are scheduled to be performed in Fall of 1999.

6.6 Feasibility Study for Deep Extraction

An independent investigation is being conducted to determine the feasibility of extracting VOCs from the two new deep wells in the SDA (see discussion in Section 6.2). A summary report will be prepared and submitted to the Agencies for review and discussion.

7. PROBLEMS/OBSTACLES ENCOUNTERED AND LESSONS LEARNED

7.1 OCVZ VVET Unit C Failure Root Analysis Report

The draft report[1] was submitted for internal review in December 1998. The report provided the results of an investigation and root cause analysis investigating the failure of Unit C, one of three operating VVET units for the OCVZ project.

A structural inspection of Unit C revealed that there were holes in the lower half of the tubes and that the mesh at the bottom of the tube sheet, which retains the ceramics inside the tubes, had failed allowing the ceramics in one tube to fall into the inlet plenum. The draft report concluded that the missing insulation on the tube sheet was the direct cause of the failure. The root cause identified was a management systems failure during fabrication and assembly of Unit C that allowed the oxidizer to be assembled without insulation on top of the tube sheet as required by the design.

Internal review of the draft report and a second failure of Unit C led to further investigation into thermal conditions which may have had potential for destroying the insulation during a high temperature event. This additional investigation and recent problems encountered when attempting to operate Unit B to the design parameters provided by Thermatrix, led to an update to the draft report. An updated report was developed (Versar 1999) that describes the sequence of events that resulted in shutdown of Unit C due to prolonged exposure to high heat resulting in failure due to thermal corrosion. The final report was submitted to the Agencies for review and discussion in Fall 1999.

7.2 Independent Engineering Review

Early in 1999, Units A and B were voluntarily shutdown by the OCVZ project team due to concerns that excess propane was being input into the units. Given the fact that the manufacturer's design specifications for propane were unknown, LMITCO upper management requested an independent engineering evaluation of the OCVZ system. Subsequently, a group of three engineers was tasked with independently evaluating and identifying a set of activities and recommendations necessary for Units A and B to resume safe and compliant operation. Their recommendations included inspections and system modifications necessary to be completed prior to restart of the units, and activities and modifications recommended for completion following unit restarts. Specifically, the team recommended: (1) a thorough visual inspection of each unit prior to restart to evaluate and remedy an damage to the units, (2) installation of additional thermocouples in each oxidizer to more precisely determine and monitor the temperatures in the oxidizer, (3) more frequent monitoring of the operating temperatures, (4) reduction of the operating temperature of each unit, (5) installation of propane flow meters on each unit, (6) maintenance of the propane flow within design specifications, (7) completion of the root cause analysis of Unit C's failure, and (8) preparation of an operational instructions document (to replace the one provided by the manufacturer).

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1. R.G. Thompson, R.O., Laing, December, 1998, *OCVZ VVET Unit C Failure Final Root Cause Analysis Report (Draft)*, INEEL/EXT-98-01102, Lockheed Martin Idaho Technologies Company.

7.3 Unit Operations

The following sections were taken out of the respective data reports. Section 7.3.1 is from *Organic Contamination in the Vadose Zone Environmental and Operational Data Report Third Quarter Operating/Shutdown Cycle 1997* (INEEL 1998). Section 7.3.2 is from *Organic Contamination in the Vadose Zone Environmental and Operational Data Report Fourth Quarter Operating/Shutdown Cycle 1997* (INELL 1998b). Section 7.3.3 is from *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, Mid-Year Operating/Shutdown Cycle 1998* (INEEL 1998c). Section 7.3.4 is from *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, End-Year Operating/Shutdown Cycle 1998* (INEEL 1999a). Section 7.3.5 is from *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, Mid-Year Operating/Shutdown Cycle 1999*, (INEEL 1999b).

7.3.1 Third Quarter 1997 Operating Cycle

Relatively few unit shut downs occurred during the third quarter 1997 operating cycle (May 7 to August 27). The majority of shutdowns were the result of scheduled power outages; the remainder were related to problems with the propane delivery system (e.g., vaporizer blowing out, propane regulator malfunctioning). These issues were dealt with quickly through routine maintenance activities and resulted in minimal unit downtime, as discussed below. The potential operating hours available for each of the three units do not include scheduled rebound periods or scheduled power outages.

Unit A operated 824 hours of a potential 954 operating hours available, resulting in 86% uptime. Unit B operated 764 hours of the 817 hours available, or 94% uptime. Unit C experienced the most uptime of 98%, or 898 hours of its available 912 hours.

Evaluation of the operating program installed in each unit and the associated programmable logic controllers (PLC), which controls unit operations based on program input/output, was completed during the operating cycle. As a result of this evaluation, efforts are currently underway to upgrade the unit PLCs in order to reduce unit downtime, minimize troubleshooting efforts, and optimize the VVET system performance on a longterm basis.

7.3.2 Fourth Quarter 1997 Operating Cycle

Units A and B experienced very few shutdowns during the fourth quarter 1997 operating cycle (September 4 to December 22). Vaporizer malfunctions and low propane flow accounted for these shutdowns. Unit A operated 2776 hours of a potential 2845 operating hours available, resulting in 98% uptime, while Unit B operated 2677 hours of the 2840 hours available, or 94% uptime. These percentages indicate that the enclosures constructed over the units and the upgrades made to the PLC in each unit are performing as anticipated by minimizing unit downtime.

Unit C, however, experienced significant downtime due to a catastrophic failure of the mesh component of its oxidizer. Of 2,848 available operating hours, Unit C experienced 2,688.5 hours (94%) downtime. This unit shutdown on September 10 during an unscheduled power outage at RWMC and efforts to restart it were unsuccessful. After routine maintenance was conducted and inspection/evaluation of mechanical components and the PLC revealed no obvious problems, attention was focused on the propane delivery system and pressure valve. Again, no obvious problems were found, although some adjustments were made to the valve setpoints. At this time, the project team contacted Thermatrix, Inc. representatives (the unit manufacturer) for assistance, and a design team consisting of Parsons Infrastructure and Technology Group, Inc. (Parsons) and LMITCO personnel was formed to evaluate the problem and recommend potential solutions. In an effort to continue maximum VOC mass removal, Well 7V was repiped from Unit C to Unit A on September 21.

Attention then turned to the oxidizer itself and the inside of Unit C's oxidizer was videotaped. This video indicated complete failure (corrosion) of the mesh beneath the tube sheet, which holds the ceramic matrix in place in the tubes. The ceramic material had fallen into the bottom of the oxidizer vessel and the insulation in the top of the oxidizer appeared scorched or discolored. Based on this video, the inside of the oxidizers at Units A and B were also videotaped. These units, however, showed no degradation or damage. Samples of the mesh were collected and analyzed onsite in an effort to determine whether the failure was caused by heat or chemical corrosion, and how much degradation had occurred. Samples have also been sent to an offsite laboratory for similar, but more rigorous, metallurgical analyses. Results have not yet been received.

At this time, preparation is underway to replace the mesh in Unit C and attempt to restart the unit, based on recommendations by the design group. On a parallel track, a root cause analysis is being conducted to determine the cause of the Unit C failure.

7.3.3 Mid-Year 1998 Operating Cycle

Units A and B experienced very few shutdowns during the mid-year 1998 operating cycle (January 5 to June 25). Low propane flow accounted for most of the shutdowns in Unit B. Units A and B were both shutdown for visual inspection of the mesh component of their respective oxidizer. Unit A operated 2,821 hours of a potential 2,880 operating hours available, resulting in 98% uptime, while Unit B operated 2,639 hours of the 2,880 hours available, or 92% uptime. Units A and B were shutdown from April 30 through June 25 in order to achieve rebound conditions. The units were started on June 29, 1998 before equilibrium conditions were totally achieved. These percentages indicate that the enclosures constructed over the units and the upgrades made to the PLC in each unit are continuing to perform as anticipated by minimizing unit downtime.

Unit C, however, continued to experience downtime this entire cycle due to its catastrophic failure in September 1997. Maximum VOC mass removal has been continued with Well 7V being repiped from Unit C to Unit A since September 21, 1997.

Based on the video footage from Unit C's oxidizer, it was imperative that the unit be repaired to facilitate continuing operations. Samples of the mesh that were collected and analyzed onsite in an effort to determine whether the failure was caused by heat or chemical corrosion have shown that the failure was caused by excessive heat. The oxidizer on Unit C was subsequently removed and dismantled. Once the oxidizer was apart, it was apparent that the Inconel tubing, attached tubesheet, and the ceramic bedding material must be replaced. The tubing was distorted and the ceramic material was black in color.

To date, Unit C has been rebuilt with new Inconel tubing, tubesheet, and ceramic bed material.

7.3.4 End-Year 1998 Operating Cycle

Units A and B were restarted on June 30, 1998, for the ninth operating cycle of OCVZ operations. Both units experienced relatively little downtime during this cycle. Unit A operated 3,809 hours of its

4,200 available operating hours, equating to 91% uptime. Approximately one half of this downtime was due to mechanical issues, while the other half was the result of routine equipment maintenance. Unit B operated 3,713 of its 4,152 available operating hours, or 90% uptime. Again, this downtime was due to both mechanical issues and routine maintenance activities.

Unit C did not operate throughout the entire operating cycle. The unit's oxidizer and ancillary equipment were rebuilt during the previous operating cycle. Restart of Unit C was attempted on July 1, 1998, but the unit was unable to sustain full operations due to apparent overheating at the exhaust plenum. Shortly thereafter, a representative from the unit's manufacturer, Thermatrix, traveled to the INEEL to assist in troubleshooting the unit, but was unable to place the unit into continuous operating mode. Evaluation of the unit continued throughout the reporting period, focusing on propane flow into the unit. The interior of Unit C's oxidizer was videotaped on December 17, 1998. The results indicated that 6 of the 12 Inconel tubes had holes through them, similar to the size and location of the holes observed following the initial failure of the unit in September 1997. Evaluation of Unit C is ongoing; however, no plans have been made to rebuild the unit at this time.

7.3.5 Mid-Year 1999 Operating Cycle

On January 13, 1999 both Units A and B were voluntarily shutdown after data collected from these units indicated propane flow into the units in excess of design parameters (as specified by the unit manufacturer). Unit A was restarted on February 15, 1999, after the propane flow was adjusted to its design parameters. It shutdown on February 20, 1999, however, when snow blew into the transformer and blew 2 fuses to the unit. The unit was not restarted again until March 24, 1999, because of extensive electrical testing following transformer repair and fuse replacement, and because of inclement weather that closed the SDA. The unit operated almost continuously throughout the rest of the reporting cycle. Of the 4,152 available operating hours, Unit A operated 3,162 hours or 76% uptime. Approximately one half of the downtime experienced was due to propane flow issues; the other half was related to weather conditions and unplanned power outages.

Restart of Unit B was unsuccessfully attempted on March 18, 1999, and March 22, 1999, following adjustment of propane flow to design parameters. A video inspection of the inside of the oxidizer tubes on April 5, 1999, indicated failure, to varying degrees, of all the tubes. Unit B disassembly commenced in April of 1999, and rebuild activities commenced mid-June of 1999. System operability testing was initiated July 13, 1999, and is currently ongoing. Unit B operated approximately 305 hours of its available 407 hours, which equates to 75% uptime. The majority of the downtime experienced was due to propane flow issues.

Unit C remained shutdown throughout the reporting cycle after discovery of its catastrophic failure on December 17, 1998. Unit C has subsequently been disassembled and rebuilt, and is currently undergoing system operability testing.

An evaluation of the propane flow to Units A and B conducted in January 1999 by the OCVZ project team indicated that propane flows in both units were 60% above the manufacturer's maximum design specifications. Subsequently, an independent engineering evaluation team was formed to evaluate this issue further. The team's assessment of the propane flow issue was consistent with the independent team's evaluation of the issue. Both parties recommended that the propane flows to the units be adjusted prior to continuing unit operations. As stated previously, the flows were adjusted, as recommended, to design specifications.

8. INTERIM PHASE II COST SUMMARY

The estimated cost for the Interim Phase II operations activities was approximately $2,000,000 (July 1997 through July 1999). This cost includes the following items as shown in Table 8-1.

Table 8-1. Estimated cost for the Interim Phase II operations.

Item	Estimated Cost
Total propane costs including tank rental and consumption for all units	$150,000
Material required for unit rebuilds, maintenance parts, and related items	$150,000
LMITCO, Parsons, and subcontract support (force account, engineers, managers, Thermatrix troubleshooting support, etc.)	$1,700,000

9. SCHEDULE FOR CONTINUATION OF PHASE II ACTIVITIES

Figure 9-1 outlines an estimated schedule for the remainder of the Phase II activities up to the issuance of the Phase III RA Report.

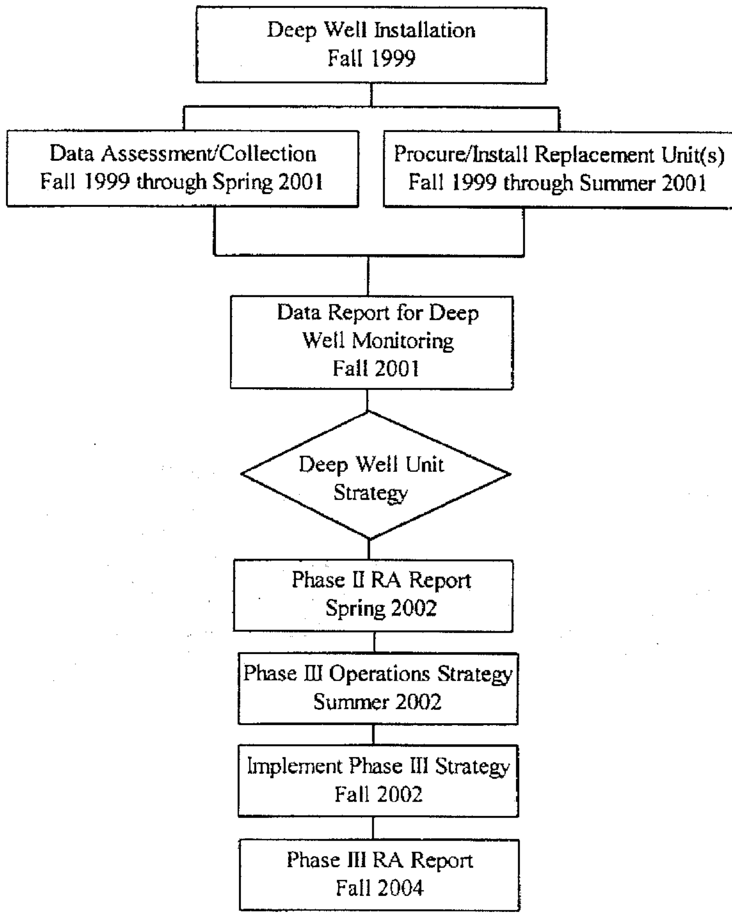

Figure 9-1. Estimated Schedule for Future OCVZ Operations.

10. ENFORCEABLE MILESTONES

The following two documents are determined to be enforceable milestones for Phase II of the VVET operations. The associated dates are for submittal of the draft documents to the Agencies.

- *Draft Phase II Remedial Action Report*, February 15, 2002
- *Draft Phase III Remedial Action Report*, September 15, 2004.

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INEEL, 1999b, *Organic Contamination in the Vadose Zone Environmental and Operational Data Report, Mid-Year Operating/Shutdown Cycle 1999*, Lockheed Martin Idaho Technologies Company, Volume 1, INEEL/EXT-99-00730, July.

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